

# Geographic variation and body size differentiation in the medium-sized species of the genus *Cybaeus* (Araneae: Cybaeidae) in northern Kyushu, Japan, with descriptions of two new species

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**Abstract** — Distribution and geographic variation of the four medium-sized species of the genus *Cybaeus* (Araneae: Cybaeidae) collected from northern Kyushu, Japan, were examined in detail. They are *C. kuramotoi*, *C. ashikitaensis*, *C. kokuraensis* n. sp. and *C. yufuin* n. sp. Of these, *Cybaeus kuramotoi* has the widest distributional range covering most of western Japan. On the other hand, distribution of *C. ashikitaensis* is separated into two disjunct areas, Kyushu and eastern part of the Chugoku Mountains of Honshu. *Cybaeus kokuraensis* and *C. yufuin* are endemic to Kyushu and have very limited distributional ranges. Of the four medium-sized species, two or three species are often sympatrically found in northern Kyushu, although the *kuramotoi*-group and *C. ashikitaensis* are parapatric in Okayama and Hyogo Prefecture, western Honshu. There is a slight difference in body size and coloration between these species when they occur sympatrically.

**Key words** — geographic variation, body size, *Cybaeus kuramotoi*, *Cybaeus ashikitaensis*, *Cybaeus kokuraensis* n. sp., *Cybaeus yufuin* n. sp.

## Introduction

The genus *Cybaeus* comprises numerous endemic species in Japan, and each of those species often has a limited distributional range. Most Japanese species of *Cybaeus* are considered to have diverged as a result of geographic isolation, probably due to their low dispersal abilities. Consequently, the species of this genus are recognized by geographic distributional pattern as well as genital morphology. Furthermore, the genus varies in body size with a wide range from ca. 3 to 15 mm, and a local species assemblage usually consists of representatives of different size classes. It is generally expected that resource competition or reproductive interference may arise when difference in body size between two closely related sympatric species are small. In *Cybaeus*, each species of the assemblage often constitutes a closely related species group together with other similar-sized species which are allopatrically or parapatrically distributed one another (Ihara 1993, 2003b). Therefore, the genus *Cybaeus* provides good opportunity to study role of morphological differentiation during speciation and formation of local species assemblages.

Within Japanese species of *Cybaeus*, a series of the medium-sized species (approximately 5–7 mm in body length) is most diverse in western Honshu (Ihara & Nojima 2004; Ihara 2006). A faunal survey and analyses of geographic differentiation of the genus revealed occurrence of four

species in northern Kyushu. They are *Cybaeus kuramotoi* Yaginuma 1963, *C. ashikitaensis* (Komatsu 1968), and two undescribed species which show close affinities to both *C. kuramotoi* and *C. ashikitaensis*. Distributional ranges of these species overlap with each other in the area, although the species of the *kuramotoi*-group show essentially a parapatric distributional pattern in Okayama and Hyogo Prefecture, western Honshu (Ihara & Nojima 2004). The purpose of the present paper is to describe complex geographic distributions and discuss relationship of these species. Intraspecific geographic variations of two known species, *C. kuramotoi* and *C. ashikitaensis*, are shown. In addition, two new species are described under the names of *C. kokuraensis* and *C. yufuin*.

## Materials and Methods

### Morphological examinations

All the measurements were made for the specimens immersed in 80% ethanol under a stereo dissecting microscope with an ocular micrometer. Body length of the specimens preserved in ethanol is liable to vary due to variable degrees of relaxation of a pedicel connecting cephalothorax and abdomen. Accordingly, I used carapace length as indicator of body size.

Female genitalia removed from the abdomen were cleared in hot 10% KOH and 3% H<sub>2</sub>O<sub>2</sub> according to the method described in Komatsu & Yaginuma (1968) to

observe internal sclerotized structure.

The type specimens designated in this paper are deposited in the National Science Museum (Natural History), Tokyo. Other specimens are in my personal collection. Data of those specimens will be given by the following order: Locality, number of individuals, date collected, and name of the collector (NT=Nobuo Tsurusaki, KM=Keiichi Mashibara, KO=Ken-ichi Okumura, YI=Yoh Ihara).

#### Recognition of species

As the medium-sized spiders of the genus *Cybaeus* show stereotyped external morphology, identification of each species relies mainly on morphology of male palp and female genitalia. I defined a taxon as an aggregation of populations which are morphologically closely similar and geographically closely distributed one another. I adopted distributional overlap of the two forms without any signs of hybridization as an evidence for two distinct species which are reproductively isolated one another. On the other hand, two completely allopatric forms were considered as two independent species when morphological gap between the two

are larger than the gap exhibited by the two forms with sympatry.

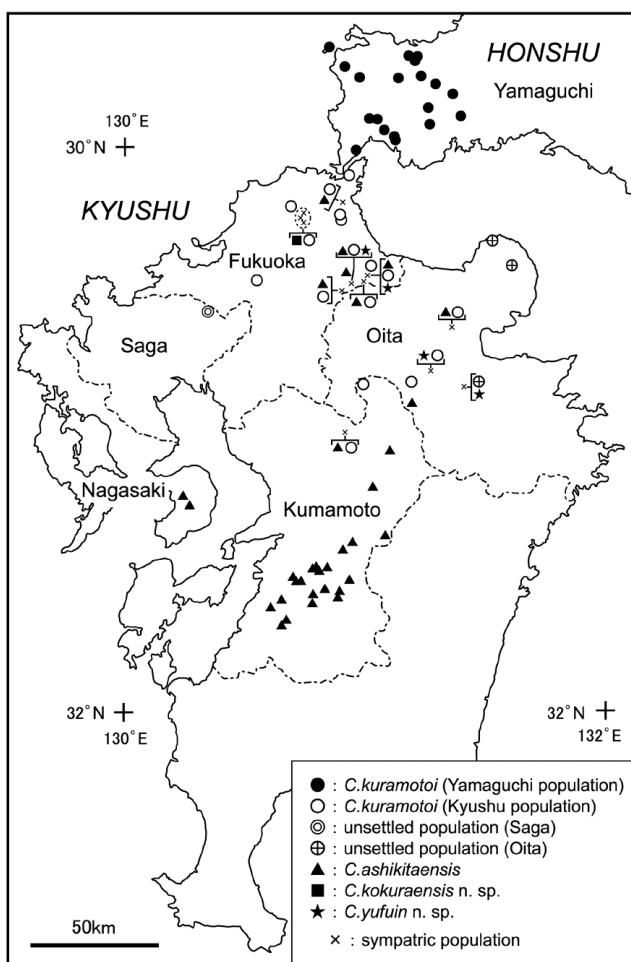
#### The medium-sized species of *Cybaeus* in northern Kyushu

##### Species included

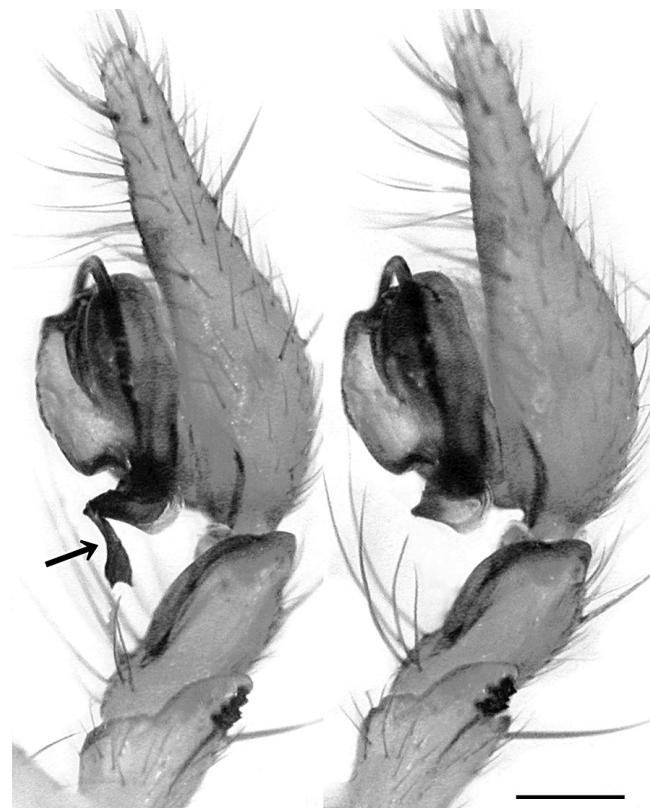
The following four forms are treated as valid species: *Cybaeus kuramotai*, *C. kokuraensis* n. sp., *C. ashikitaensis*, and *C. yufuin* n. sp.

##### Geographic distributions

Figure 1 shows distributions of these medium-sized species in the study area. Of these, distributional range of *Cybaeus kuramotai* is most widespread. This species is originally described from Akiyoshi-dai, Yamaguchi Prefecture in westernmost Honshu, and is widely distributed over western Japan, corresponding to the western Honshu, northern Kyushu and northern Shikoku (Ihara 2003a, unpublished data; Irie & Ono 2003). On the other hand, distributional range of *C. ashikitaensis* is separated into two distant areas, eastern part of the Chugoku Mountains (Okayama and Hyogo Prefectures) in Honshu and Kyushu (Ihara 2003a; Ihara & Nojima 2004). This species is sympatrically distributed with *C. kuramotai* over a wide



**Fig. 1.** The distributions of four medium-sized species in northern Kyushu.



**Fig. 2.** Male palp in pre- and postcopulation of *Cybaeus kuramotai* (Moji-ku, Kitakyushu-shi, Fukuoka Prefecture) — lateral views of the male left palp: left, intact palpal conductor with apical element (arrowed); right, conductor whose apical element broken off. (Scale: 0.2 mm)

range in Fukuoka and Oita Prefecture, although both species are allopatric in western Honshu (Ihara & Nojima 2004). In contrast, two new species, *C. kokuraensis* and *C. yufuin*, are endemic to Kyushu and have very limited distributional range.

### Geographic variation and description of the species

*Cybaeus kuramotoi* Yaginuma 1963  
[Japanese name: Nagato-namihagumo]  
(Figs. 2–6, 8A–B, 9C–D, 13B)

*Cybaeus kuramotoi* Yaginuma 1963, p. 57, (Female holotype from Kōmori-anan Cave, 13-V-1962, and male paratype from Yurino-anan Cave, 20-X-1962, Akiyoshi-dai, Yamaguchi Prefecture, Honshu, Japan, collected by Tadashi Kuramoto, not examined.); Yaginuma 1986, p. 145, fig. 78 (4); Ihara 2003a, p. 55, figs. 2, 6, 12, 15, 18–19, 22–23; Irie & Ono 2003, p. 180, figs. 12, 14, 16, 21–22.

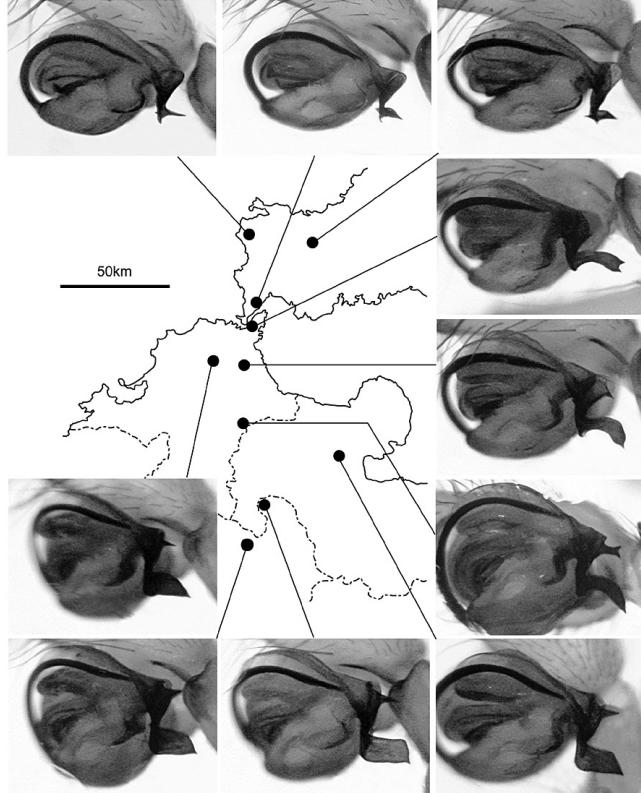
**Distribution.** Kyushu, northern part of Shikoku and western Honshu (Ihara 2003a, unpublished data; Irie & Ono 2003).

**Geographic variation.** One of the prominent characteristics of *Cybaeus kuramotoi* is occurrence of mating plug which corresponds to an apical element of palpal embolus

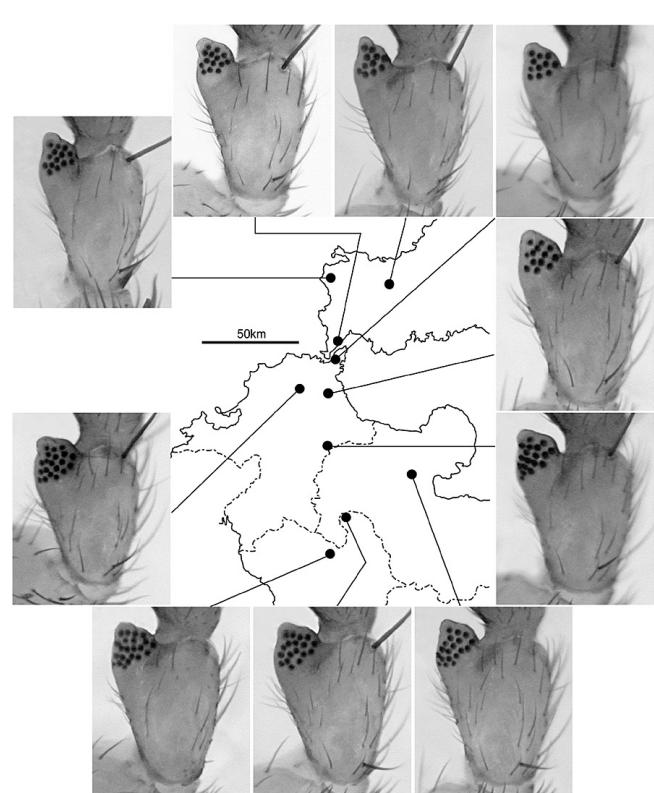
(Fig. 2) that is broken off from the remaining part of male palp and is inlaid to a crevice of epigynal plate to block a copulatory pore of females after copulation (Irie & Ono 2003; Ihara & Nojima 2004; Ihara 2006). Shape of the apical element of male palpal embolus shows considerable degree of geographic variation (Fig. 3). The apical element is more developed in Kyushu populations than in Yamaguchi populations including type locality. In Kyushu, it is narrow and curved in northern populations while it becomes broad in southern populations. Shape of patellar apophysis of male palp and the number of conical teeth on the apophysis also vary among the populations (Fig. 4). The patellar apophysis tends to become wider and the conical teeth increase in number toward the south within the range of distribution.

On the other hand, in female, shape of opening of epigynum varies between populations in Yamaguchi and Kyushu (Fig. 5). The genital opening of Yamaguchi population becomes wide toward the backward. However, no remarkable geographic variation is found in internal structure of female genitalia (Fig. 6). Since the internal structures of female genitalia conform to each other, it is considered that they are the same species.

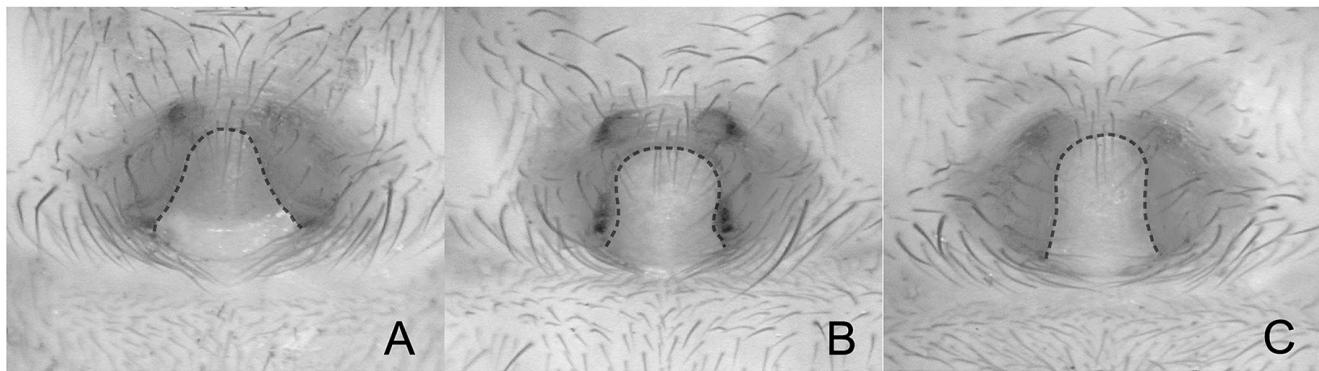
**Specimens examined.** FUKUOKA PREF. Kitakyushu-shi, Moji-ku, Motokiyotaki, 2♂6♀, 23-XI-1998, YI & Megumi Ihara. Kokura-minami-ku, Michihara, Sugao-notaki Falls: 1♀, 2-XII-1993, NT; 1♀, 2-X-1995, NT; 5♂9♀,



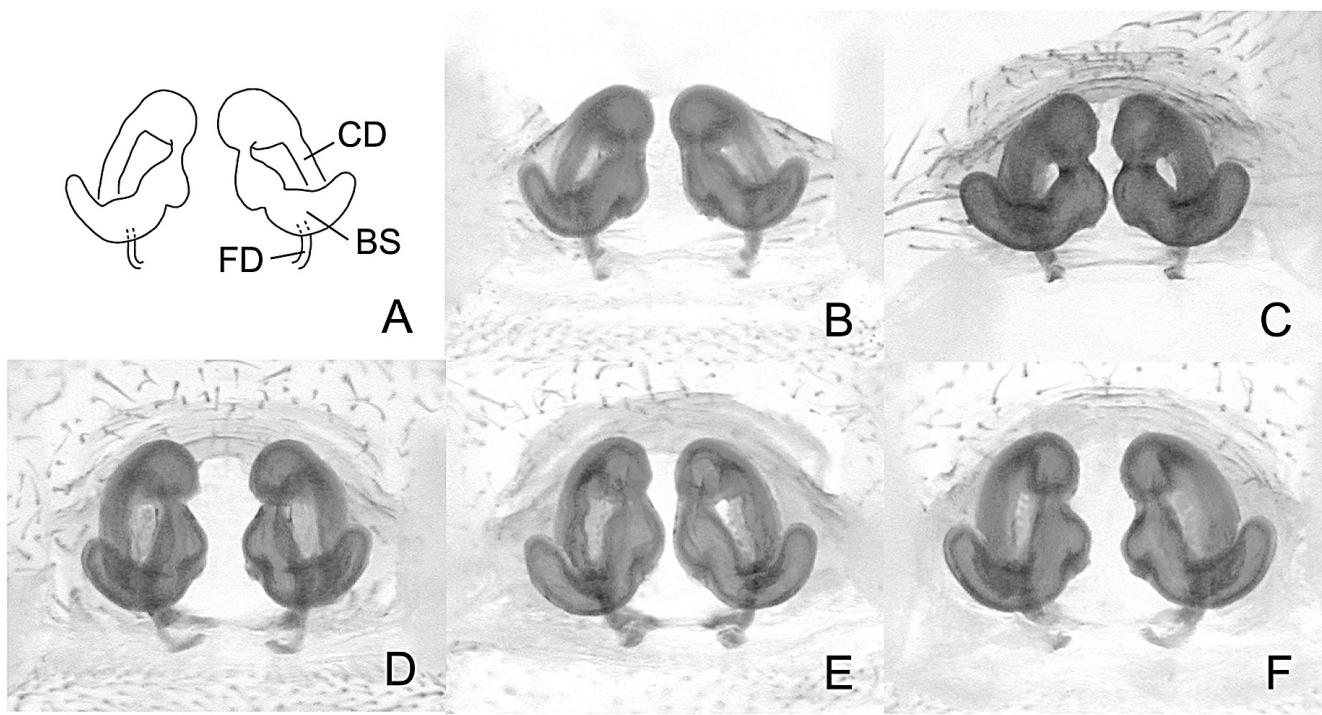
**Fig. 3.** Geographic variation of male palp of *Cybaeus kuramotoi* in Kyushu and Yamaguchi Prefecture: the apical element of conductor of left palp, ventrolateral view.



**Fig. 4.** Geographic variation of male palp of *Cybaeus kuramotoi* in Kyushu and Yamaguchi Prefecture: the patellar apophysis of left palp, dorsolateral view.



**Fig. 5.** Geographic variation of female genitalia of *Cybaeus kuramotai* in Kyushu and Yamaguchi Prefecture — epigynum, the shape of genital opening, ventral view: A, Akiyoshi-dai, Yamaguchi Prefecture, westernmost Honshu; B, Moji, Fukuoka Prefecture, northern Kyushu; C, Kikuchi-keikoku, Kumamoto Prefecture, central Kyushu. (Dashed line: edge of epigynal plate, Scale: 0.5 mm)



**Fig. 6.** Female genitalia of *Cybaeus kuramotai* in Kyushu and Yamaguchi Prefecture — internal structure of genitalia, dorsal view: A, connection of spermathecae and ducts (BS, spermathecal base; CD, copulatory duct; FD, fertilization duct); B, Akiyoshi-dai, Yamaguchi Prefecture; C, Nagano-gankai, Fukuoka Prefecture; D, Mt. Hikosan, Fukuoka Prefecture; E, Kikuchi-keikoku, Kumamoto Prefecture; F, Ajimu-machi, Oita Prefecture. (Scale: 0.5 mm)

21-XI-2004, YI. Kokura-minami-ku, Nagano-gankai, 1♀, 19-XI-1994, KM. Yahata-nishi-ku: Mt. Shakudake, 1♀, 3-X-1995, NT; Hata, 2♂, 28-XI-2004, YI. Nogata-shi: Tonno, 2♀, 28-XI-2004, YI; Kamitonno, Ryuo-kyo, 1♀, 28-XI-2004, YI. Yukuhashi-shi, Yayama, 13♂17♀, 13-X-1993, YI. Buzen-shi: Kubote, 3♀, 19-XI-1994, YI, 1♀, 27-XI-2005, YI; Mt. Inugadake, 1♀, 19-XI-1994, YI; Hata, 2♂3♀, 27-XI-2005, YI. Dazaifu-shi, Uchiyama, the start of a mountain trail to Mt. Homanzan, 4♀, 30-III-1994, YI. Tagawa-gun, Soeda-machi, Mt. Hikosan, 2♂5♀, 9-X-1995, YI. Miyako-

gun, Miyako-machi, Hobashira, surrounding of Jabuchi campsite: 3♂2♀, 19-XI-2005, YI; 1♂4♀, 7-IV-2006, YI. OITA PREF. Nakatsu-shi, Yabakei-machi, Shin-yabakei, Kin-un-kyo, 1♀, 1-XII-1993, NT. Usa-shi, Ajimu-machi, Suzuki, 1♂7♀, 11-X-1993, YI. Yufu-shi, Yufuin-chō, Kawanishi, northern foot of Mt. Noine-dake: 2♀, 10-X-1993, YI; 1♂, 10-X-1993, M. Ihara; 6♂7♀, 10-X-1995, YI. Kusu-gun: Kokonoe-machi, Kyusui-kei, 1♀, 30-XI-1993, NT; Kusu-machi, 1♀, 3-V-2005, KO. KUMAMOTO PREF. Kikuchi-shi, Kikuchi-keikoku Valley: 2♂2♀, 12-X-1993,

YI; 3♀, 12-X-1993, M. Ihara. Aso-gun, Oguni-machi, Kurobuchi, 2♂, 1-X-1998, YI.

*Cybaeus ashikitaensis* (Komatsu 1968)  
[Japanese name: Ashikita-namihagumo]  
(Fig. 8C-D, 13C)

*Dolichocybaeus ashikitaensis* Komatsu 1968, p. 20, figs. 14, 30, 46, 62, 73, 78, 95. (Female holotype from Ashikita Cave, Kumamoto Prefecture, Kyushu, Japan, collected by Teruo Irie,

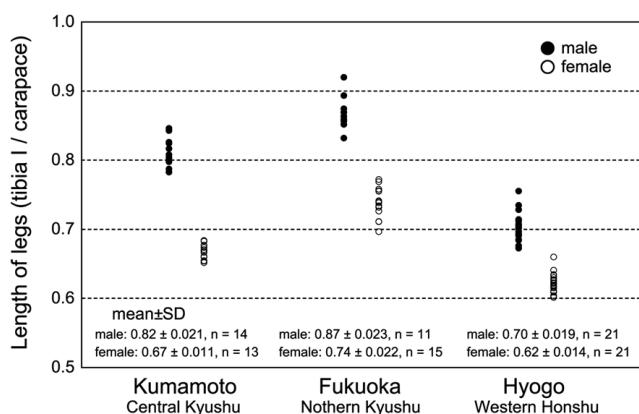


Fig. 7. Geographic variations of length of legs (tibia I / carapace) in *Cybaeus ashikitaensis*.

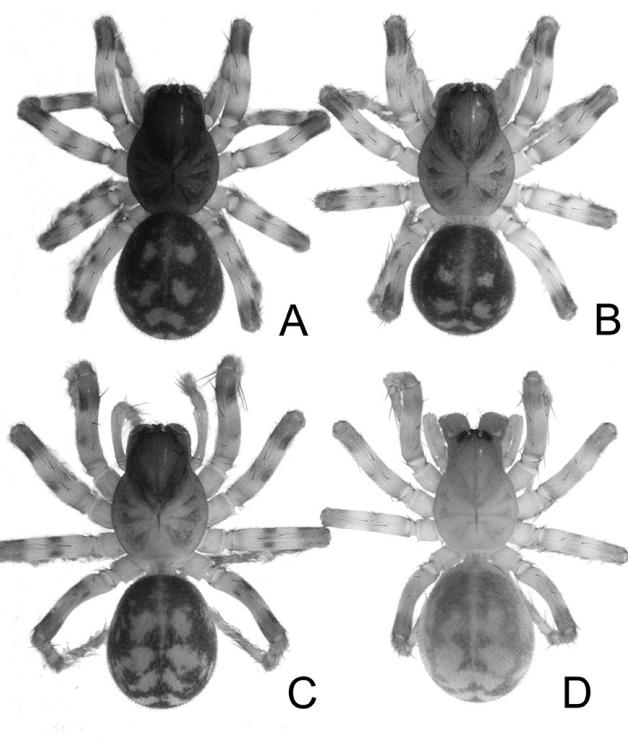


Fig. 8. Coloration patterns of *Cybaeus kuramotoi* and *C. ashikitaensis* which are sympatrically found from Fukuoka Prefecture (7-IV-2006, Jabuchi-no-taki Falls, Miyako-machi) — A-B, *C. kuramotoi*; C-D, *C. ashikitaensis*. (Scale: 2.0 mm)

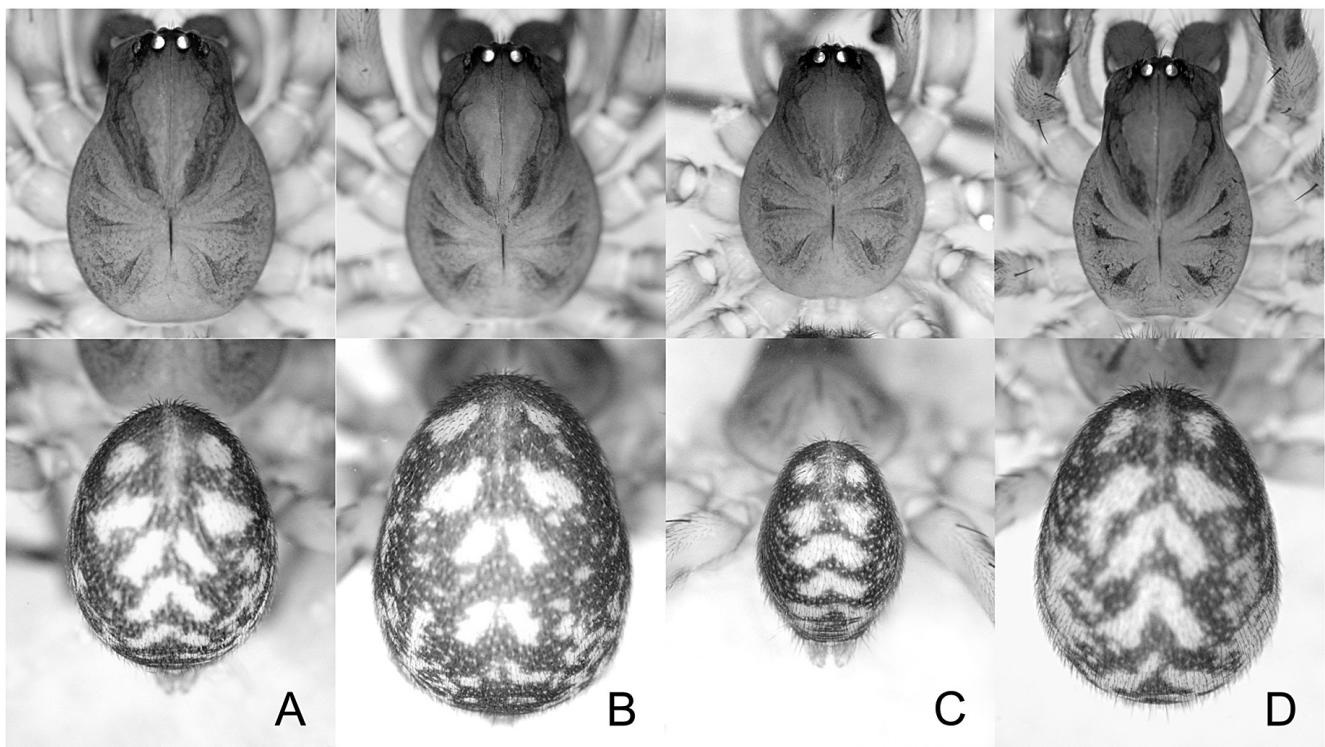


Fig. 9. Shape of carapace and coloration pattern of abdomen of *Cybaeus kokuraensis* and *C. kuramotoi* in same locality: A, *C. kokuraensis*, male (holotype); B, *C. kokuraensis*, female (paratype); C, *C. kuramotoi*, male; D, *C. kuramotoi*, female — above: carapace, dorsal view; below: abdomen, dorsal view. (Scale: 2.0 mm)

28-VIII-1965, not examined.)

*Cybaeus ashikitaensis*: Yaginuma 1986, p. 145, fig. 77 (9); Irie & Ono 2000, p. 177, fig. 11; Ihara 2003a, p. 55, figs. 3, 7, 11, 14; Ihara & Nojima 2004, p. 143, figs. 7–8, 11, 20–21.

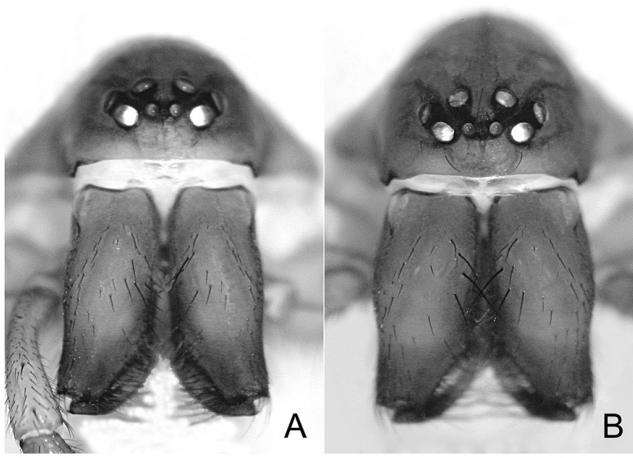
**Distribution.** Kyushu and western Honshu (Ihara 2003a; Ihara & Nojima 2004).

**Geographic variation.** *Cybaeus ashikitaensis* was originally described from Ashikita Cave, Kumamoto Prefecture, central Kyushu and distributed over northern half of Kyushu

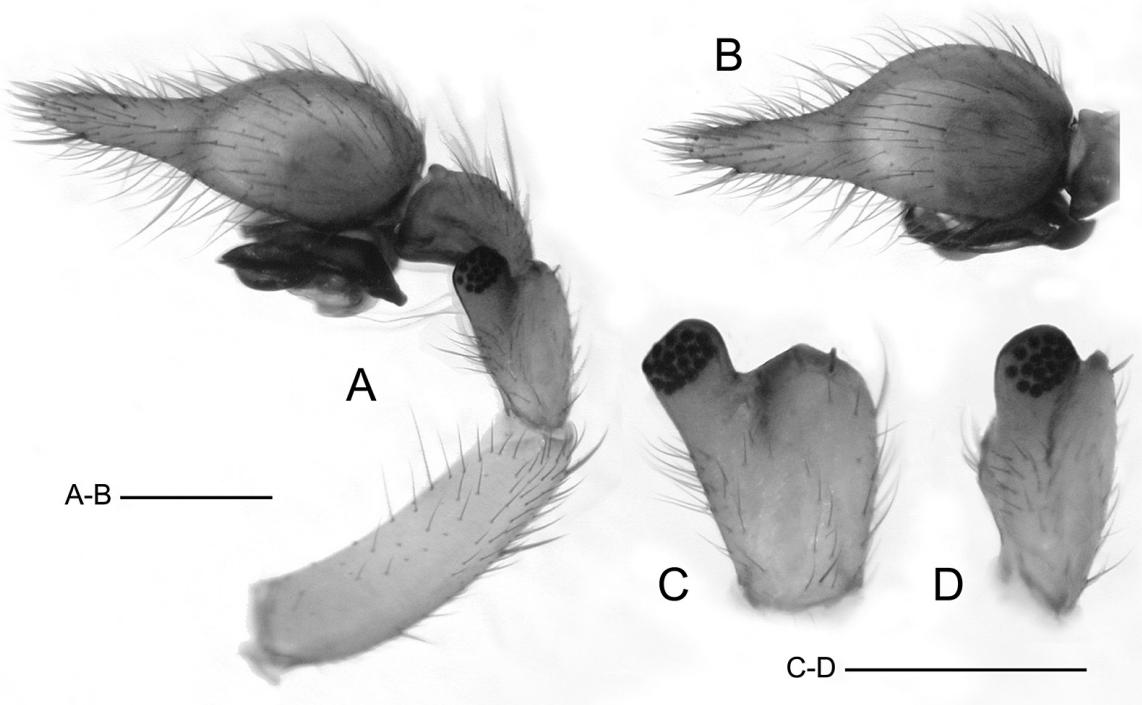
(Ihara 2003a). Furthermore, it is also distributed in Okayama and Hyogo Prefectures, western Honshu. Two distributional ranges of *C. ashikitaensis* are widely separated by the intervening populations of *C. kuramotoi* and its closely related species (Ihara & Nojima 2004). No significant difference is found in the morphology of male palp and female genitalia between the populations of Kyushu and Honshu. However, legs remarkably vary in length among the populations (Fig. 7). Legs of specimens from Kyushu are significantly longer than those from Hyogo Prefecture, western Honshu. Further, within Kyushu, specimens from northern area (Fukuoka Prefecture) have longer legs than those of southern area (Kumamoto Prefecture).

*Cybaeus kuramotoi* and *C. ashikitaensis* are sympatrically distributed in a wide range of northern Kyushu. When these species inhabit sympatrically, *C. ashikitaensis* tends to be paler in coloration than *C. kuramotoi* (Fig. 8).

**Specimens examined.** FUKUOKA PREF. Kitakyushu-shi, Kokura-minami-ku, Nagano, Nagano-gankai: 2♂, 15-I-1994, KM; 1♂1♀, 13-XI-1994, KM; 2♂2♀, 13-XI-1994, KM & Tadashi Kuramoto; 1♂3♀, 19-XI-1994, KM. Buzen-shi: Mt. Inugadake, 2♂, 19-XI-1994, YI; Kubote, 10♂5♀, 27-XI-2005, YI. Tagawa-gun, Soeda-machi, Hikosan, 1♀, 9-X-1995, YI. Miyako-gun, Miyako-machi: Kami-irahara, 1♂, 19-XI-2005, YI; Hobashira, surrounding of Jabuchi campsite, 2♀, 19-XI-2005, YI, 1♂8♀, 7-IV-2006, YI; Hobashira, No-toge, 2♀, 19-XI-2005, YI. NAGASAKI PREF. Unzen-shi: Obama-chō, Unzen, Mt. Yadake, 2♀, 29-XI-1993, NT; Chijiwa-chō, 2♂, 24-IX-2004, KO; Ikenohara, 1♂, 7-X-



**Fig. 10.** Sexual dimorphism in head region and chelicerae of *Cybaeus kokuraensis*, frontal view — A, male, holotype; B, female paratype. (Scale: 0.5 mm)



**Fig. 11.** Male left palp of *Cybaeus kokuraensis* (holotype) — A, lateral view; B, cymbium, dorsal view; C, patella, dorsolateral view; D, patella, lateral view. (Scales: 0.5 mm)

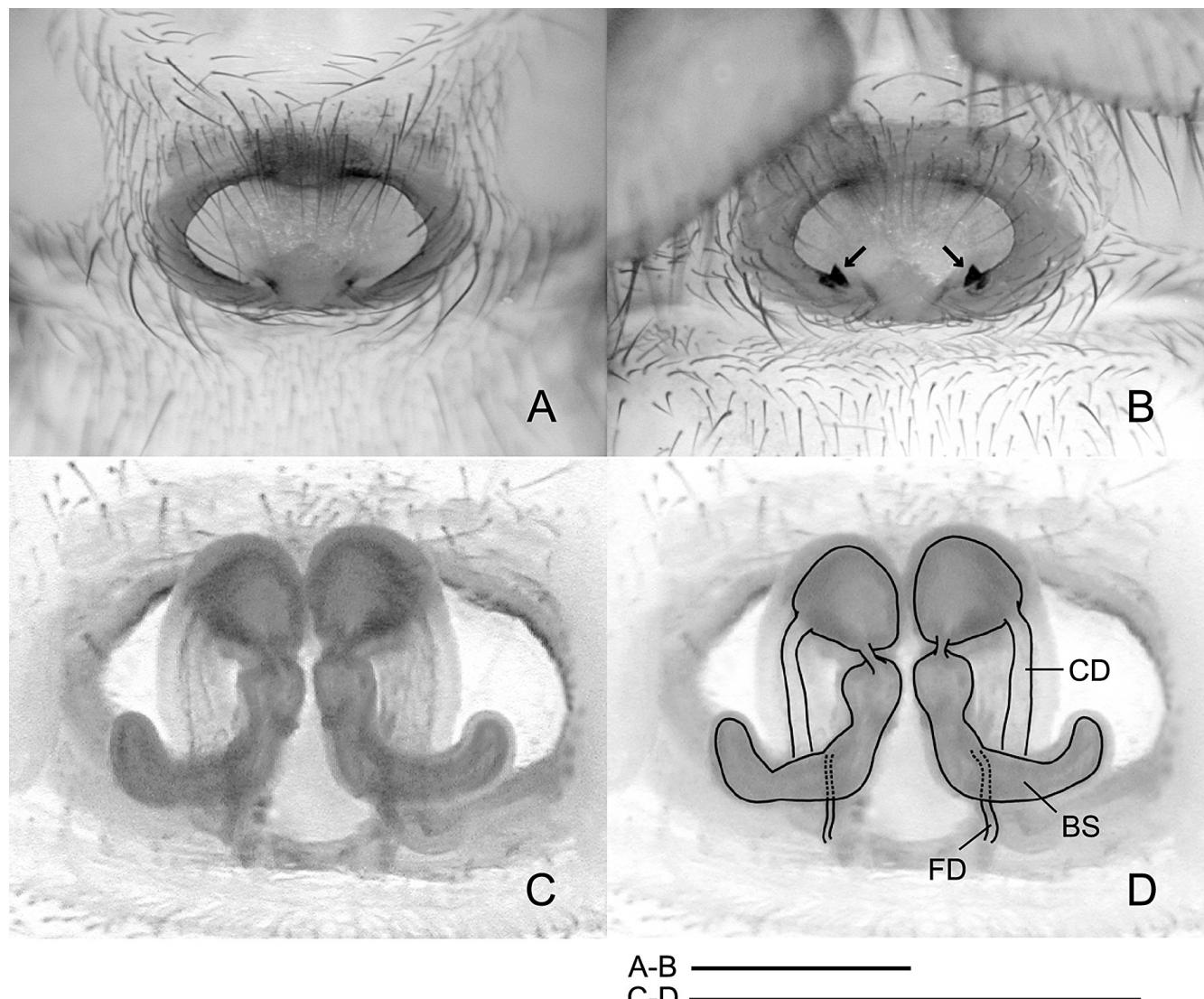
2005, KO. OITA PREF. Usa-shi, Ajimu-machi, Kayagomori, 3♂1♀, 11-X-1993, YI. Kusu-gun, Kokonoe-machi, Tano, Makinoto-tōge, 1♀, 12-X-1993, YI. KUMAMOTO PREF. Yatsushiro-shi: Sakamoto-machi, Fukami, 7♂11♀, 13-X-2001, YI; Nakatani, 29♂20♀, YI; Nakatsumichi, Nishikamase, 3♂7♀, 14-X-2001, YI; Izumi-machi, Kureko, 12♂17♀, 15-X-2001, YI; Nitao, 5♂6♀, 15-X-2001, YI. Kikuchi-shi, Kikuchi-keikoku Valley, 1♂2♀, 12-X-1993, YI. Aso-shi, Ichinomiya-machi, Miyaji, 8♂4♀, 1-X-1998, YI. Shimomashiki-gun, Misato-machi, Kashiwagawa, 12♂16♀, 16-X-2001, YI. Aso-gun, Minami-aso-mura, Kugino, 1♂, 10-I-1990, YI. Kamimashiki-gun, Yamato-machi, Midorikawa, Midorikawa Valley, 19-II-1990, 1♀, YI. Ashikita-gun, Ashikita-machi, between Kaiji and Uwabaru, 16♂15♀, 14-10-2001, YI. Kuma-gun, Kumamura, Kōnose: between Yokoi and Takazawa, 13♂9♀, 14-

X-2001, YI; between Takazawa and Ōse, 7♂13♀, 14-X-2001, YI. Itsuki-mura: Irikamo, 1♀, 28-III-2001, YI; Hei, Motoidani, 14-X-2001, 2♂3♀, YI; Shimo-kajihara, 8♂6♀, 15-X-2001, YI; Otsu, 3♂1♀, 15-X-2001, YI; Kakehashi, 1♂6♀, 14-X-2001, YI; Mt. Shirakami, 16♂16♀, 15-X-2001, YI; northwestern foot of Mt. Shirakami, 4♀, 15-X-2001, YI; Hirase, Shimo-hirase, 24♂18♀, 14-X-2001, YI; Shiiba, 2♂6♀, 15-X-2001, YI.

#### *Cybaeus kokuraensis* n. sp.

[Japanese name: Kokura-namihagumo]  
(Figs. 9A-B, 10-12, 13A)

*Description.* Male (holotype, NSMT-Ar 6803). Measurements (in mm). Body length 4.95; carapace length 3.00, width 2.14, head region width 1.24; abdomen length



**Fig. 12.** Female genitalia of *Cybaeus kokuraensis* (paratypes) — A, epigynum, ventral view; B, epigynum with mating plugs (arrowed); C, internal structure, dorsal view; D, connection of spermathecae and ducts, dorsal view. (BS, spermathecal base; CD, copulatory duct; FD, fertilization duct; Scales: 0.5 mm)

2.76, width 2.15. Ocular area: length 0.37, width 0.78. Sternum length 1.41, width 1.34; labium length 0.32, width 0.41. Length of legs (femur/ patella/ tibia/ metatarsus/ tarsus; total): Leg I: 2.54/ 0.92/ 2.41/ 2.36/ 1.54; 9.77. Leg II: 2.43/ 0.91/ 2.18/ 2.22/ 1.43; 9.17. Leg III: 2.16/ 0.83/ 1.68/ 2.10/ 1.20; 7.97. Leg IV: 2.63/ 0.84/ 2.33/ 2.76/ 1.38; 9.94.

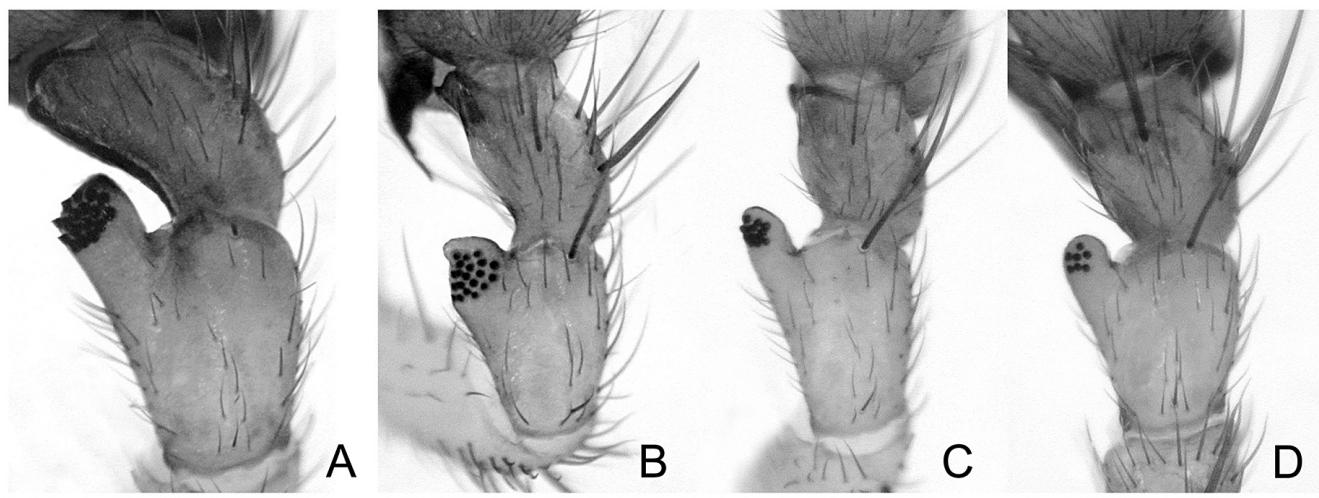
Head region narrow, ratio of width to thoracic region 0.58 (Fig. 9A). Thoracic region higher than head region. Anterior eye row slightly procurved as seen from front, posterior eye row slightly recurved as seen from above. Anterior median eyes the smallest and smaller than half to other eyes (Fig. 10A). Ocular area about twice as wide as long. Clypeus slightly shorter than length of median ocular area, 0.88 in ratio. Chelicera geniculate in front, promargin of fung furrow with 3 teeth, retromargin with 4 (or 3) teeth and 4 (or 5) denticles, and basally with lateral condyle. Length of legs: 4>1>2>3. Tibia I with 2-2-2 ventral spines, 2 prolateral spines and 2 retrolateral spines; metatarsus I with 2-2-3 ventral spines, 4 prolateral spines and 1 retrolateral spine; tibia II with 2-2-1(retromargin)-2 ventral spines, 3 prolateral spines and 2 retrolateral spines; metatarsus II 2-2-3 ventral spines, 4 prolateral spines and 2

retrolateral spines.

Palp (Figs. 11, 13A). Relatively thick and short in proportion (Fig. 11A). Cymbium broad in prolateral side (Fig. 11B). Patellar apophysis square, relatively long, furnished with 16 conical teeth (Fig. 11C-D). Tibia slightly short, bent for prolateral side (Fig. 13A). Conductor with small triangle apical element of embolus.

Coloration. Carapace yellowish brown with reticulate olive black markings on lateral sides of the head and radical bands on the thorax. Chelicerae, maxillae, labium and sternum bright yellowish brown; chelicerae darker than the others. Legs bright yellowish brown with olive black annulations. Dorsum of abdomen olive black with pale yellow chevron pattern as shown in Fig. 9A.

Female (one of paratypes, NSMT-Ar 6804). Measurements (in mm). Body length 6.25; carapace length 2.85, width 2.05, head region width 1.34; abdomen length 3.73, width 2.70. Ocular area: length 0.33, width 0.81. Sternum length 1.31, width 1.24; labium length 0.31, width 0.43. Length of legs (femur/ patella/ tibia/ metatarsus/ tarsus; total): Leg I: 2.25/ 0.94/ 2.03/ 1.86/ 1.08; 8.16. Leg II: 2.20/ 0.90/ 1.81/ 1.79/ 1.04; 7.74. Leg III: 1.98/ 0.83/ 1.42/ 1.74/



**Fig. 13.** Tibia and patella of male left palp, dorsal view — A, *C. kokuraensis* (holotype); B, *C. kuramotoi* (Kokura-minami-ku, Kitakyushu-shi); C, *C. ashikitaensis* (Ashikita-machi, Kumamoto Prefecture); D, *C. yufuin* (holotype). (Scale: 0.5 mm)

**Table 1.** Comparison of some diagnostic characters of five species of the medium-sized *Cybaeus* in Kyushu and western Honshu

	<i>C. kokuraensis</i>	<i>C. kuramotoi</i>	<i>C. ashikitaensis</i>	<i>C. yufuin</i>	<i>C. akiensis</i>
Highest region of carapace	Thoracic region	Thoracic region	Thoracic region	Head region	Head region
Ventral spines of metatarsus I	2-2-3 / 2-2-2	2-2-2	2-2-2	2-2-3 / 2-2-2	2-2-3
Male palpal tibia	Long and bent	Long	Intermediate	Short	Short
Male palpal patella	Long	Long	Long	Short	Short
Epigynum (Gonopore)	Slightly concave	Concave	Slightly concave	Flat	Flat
Spermathecal base	Long and turn to forward	Long	Long	Short (Sphere)	Short (Sphere)
Mating plug	Small	Large	Absent	Absent	Absent
Distribution	Northern Kyushu	Western Honshu/ Kyushu	Kyushu/ Western Honshu	Northern Kyushu	Westernmost Honshu
Retreat	Two openings	Two openings	Two openings	Unknown	Two openings with an additional loophole

0.92; 6.89. Leg IV: 2.40/ 0.84/ 2.02/ 2.37/ 1.10; 8.73.

Similar to male in coloration. Carapace longer than male. Head region larger and higher, ratio of width to thoracic region 0.65 (cf. Figs. 9B with 9A, 10B with 10A). Chelicera more geniculate (Fig. 10B). Abdomen larger and more rounded (cf. Fig. 9B with 9A), legs shorter than those of male. Tibia I with 2-2-2 ventral spines and 2 prolateral spines; metatarsus I with 2-2-2 ventral spines, 1 prolateral spine and 1 retrolateral spine; tibia II with 2-2-1 (retromargin)-2 ventral spines and 4 prolateral spines; metatarsus II 2-2-3 ventral spines, 4 prolateral spines and 1 retrolateral spine.

Genitalia (Fig. 12). Epigynum simple, with very large and ellipse opening (Fig. 12A). A pair of copulatory pores on both sides of posterior end. Spermathecal bases long and

turn to forward (Fig. 12C-D).

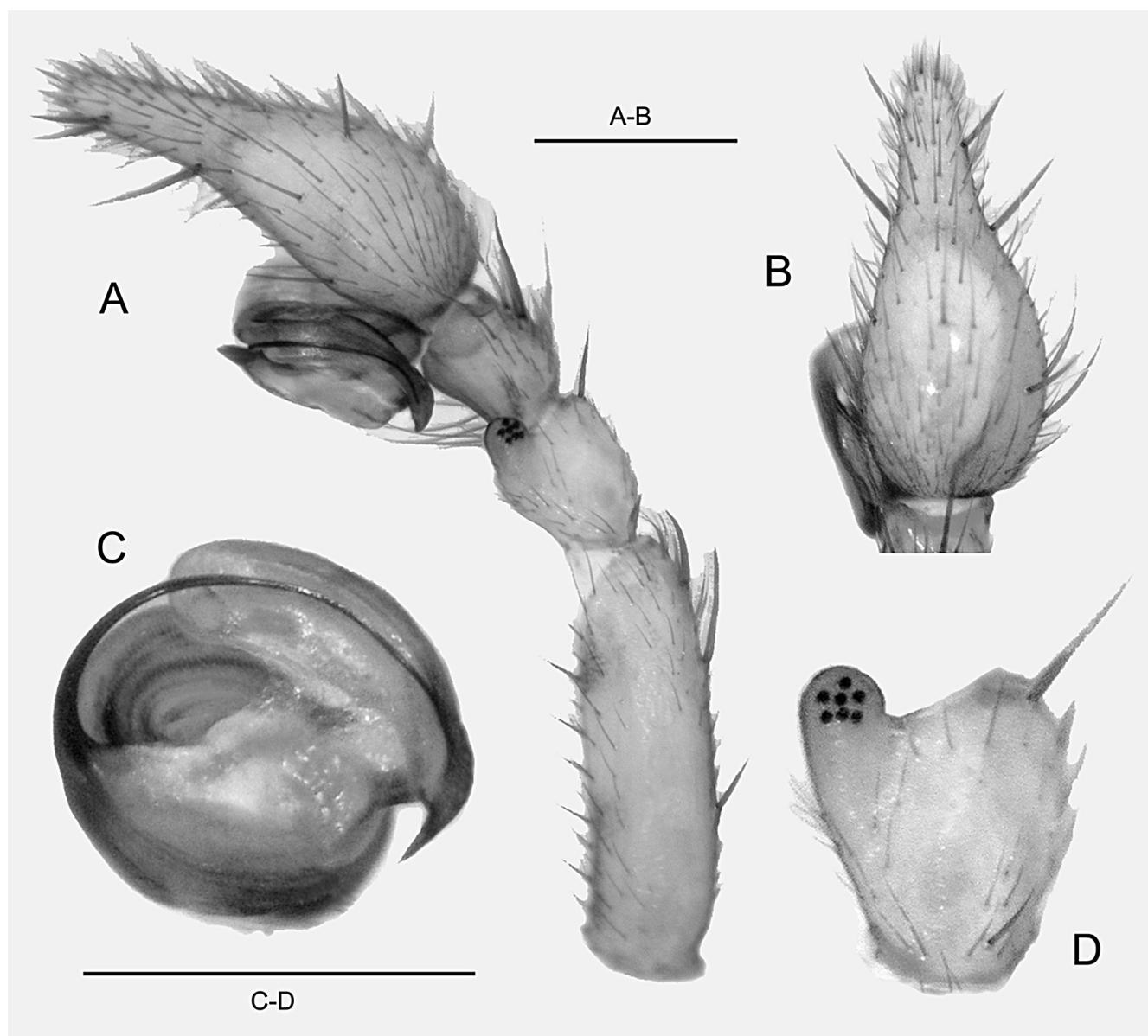
*Type series.* Sugao-no-taki Falls, Michihara, Kokuraminami-ku, Kitakyushu-shi, Fukuoka Pref., Japan: holotype (♂, NSMT-Ar 6803); paratypes (2♀, NSMT-Ar 6803-6804), 21-XI-2004, Y. Ihara leg.

*Other specimens examined.* FUKUOKA PREF. Same locality and date as the type series, 4♂7♀, YI. Nōgata-shi: Tonno, Fukuchiyama Dam, 5♀, 28-XI-2004, YI; Kamitonna, Ryūō-kyō, 8♀, 28-XI-2004, YI.

*Distribution.* Fukuoka Prefecture, Northern Kyushu, Japan (Fig. 1).

This species has been found in a very limited area, and the collected localities are within the distributional range of *C. kuramotoi*.

*Variation.* No prominent variation is found in the mor-



**Fig. 14.** Male left palp of *Cybaeus yufuin* (holotype) — A, lateral view; B, cymbium, dorsal view; C, genital bulb, ventral view; D, patella, dorsolateral view. (Scales: 0.5 mm)

phology of male palp and female genitalia, probably due partly to its narrow range of distribution.

Range of body size (in mm, means $\pm$ SD in parentheses; male n=5, female n=22): Carapace length, 2.85-3.15 (3.03) in male, 2.08-3.02 (2.58 $\pm$ 0.309) in female; carapace width, 2.11-2.32 (2.20) in male, 1.48-2.14 (1.82 $\pm$ 0.207) in female. The carapace of male is significantly longer than that of female. Furthermore, degree of variation in carapace length of male is lower than that of female, though numbers of male specimens are inadequate.

**Remarks.** Comparison of some diagnostic characters of *C. kokuraensis* n. sp., *C. yufuin* n. sp. and three related species are summarized in Table 1. Shapes of male palpal tibia and patella are also key characters to distinguish the present species from other medium-sized species (Fig. 13).

Mating plug of *Cybaeus kokuraensis* is very small (Fig.

12B) compared with *C. kuramotoi* and *C. jinsekiensis* Ihara 2006, the latter of which is also designated in the *kuramotoi*-group (Ihara 2006). The plug is a small fragment originating from an apical element of embolus of male palp, and plugged up only copulately pore.

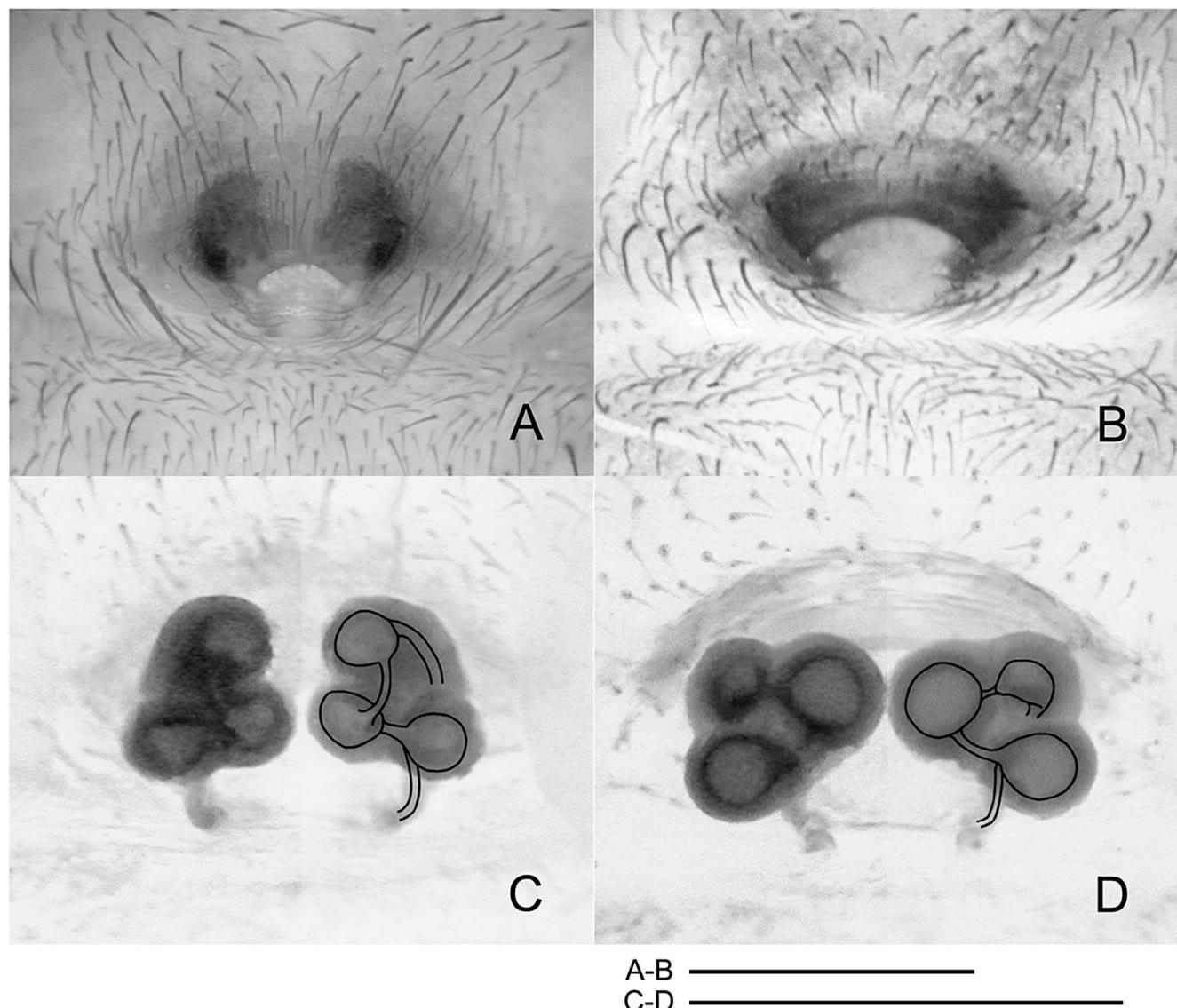
#### *Cybaeus yufuin* n. sp.

[Japanese name: Yufuin-namihagumo]

(Figs. 13D, 14, 15A, C)

*Cybaeus* sp., Irie & Ono 2003, p. 181, figs. 7-11, 13, 15, 17-20.

**Description.** Male (holotype, NSMT-Ar 6806). Measurements (in mm). Body length 5.60; carapace length 2.99, width 2.06, head region width 1.23; abdomen length 2.68,



**Fig. 15.** Female genitalia of *Cybaeus yufuin* (paratype) and *C. akiensis* (paratypes): A & C, *C. yufuin*; B & D, *C. akiensis* — A-B, epigynum, ventral view; C-D, internal structure, dorsal view. (Scales: 0.5 mm)

width 2.23. Ocular area: length 0.34, width 0.76. Sternum length 1.39, width 1.27; labium length 0.32, width 0.46. Length of legs (femur/ patella/ tibia/ metatarsus/ tarsus; total): Leg I: 2.14/ 0.89/ 1.95/ 1.90/ 1.29; 8.17. Leg II: 2.02/ 0.88/ 1.79/ 1.84/ 1.23; 7.76. Leg III: 1.94/ 0.83/ 1.42/ 1.80/ 1.02; 7.01. Leg IV: 2.39/ 0.81/ 2.05/ 2.50/ 1.32; 9.07.

Head region narrow, ratio of width to thoracic region 0.60. Head region higher than thoracic region. Anterior eye row slightly procurved as seen from front, posterior eye row straight as seen from above. Anterior median eyes the smallest, about half to other eyes. Ocular area twice as wide as long. Clypeus shorter than length of median ocular area, 0.73 in ratio. Chelicera geniculate in front, promargin of fung furrow with 3 teeth, retromargin with 4 (or 3) teeth and 4 (or 5) denticles, and basally with lateral condyle. Length of legs: 4>1>2>3. Tibia I with 2-2-2 ventral spines, 2 prolateral spines and 2 retrolateral spines; metatarsus I with 2-2-3 ventral spines, 4 prolateral spines and 1 retrolateral spine; tibia II with 2-2-1(retromargin)-2 in left and 2-2-0-2 in right ventral spines, 2 prolateral spines and 2 retrolateral spines; metatarsus II 2-2-3 ventral spines, 3 (left) or 4 (right) prolateral spines and 2 retrolateral spines.

**Palp** (Figs. 13D, 14). Relatively thick and short in proportion (Fig. 14A). Tibia slightly shorter than patella (Fig. 13D). Patellar apophysis short and round, furnished with 7 conical teeth (Fig. 14D). Conductor simple without apical element of embolus (Fig. 14C).

**Coloration.** Carapace glossy dark reddish brown on the head and yellowish brown on the thorax, with reticulate olive black markings on lateral sides of the head and radical bands on the thorax. Chelicerae dark reddish brown, maxillae, labium and sternum bright yellowish brown. Legs light yellow with brownish black annulations. Dorsum of abdomen olive black with light yellow chevron pattern.

Female (one of paratypes, NSMT-Ar 6808). Measure-

ments (in mm). Body length 6.15; carapace length 2.98, width 1.89, head region width 1.35; abdomen length 3.30, width 2.46. Ocular area: length 0.36, width 0.79. Sternum length 1.31, width 1.20; labium length 0.32, width 0.44. Length of legs (femur/ patella/ tibia/ metatarsus/ tarsus; total): Leg I: 2.09/ 0.86/ 1.72/ 1.59/ 1.02; 7.28. Leg II: 1.97/ 0.84/ 1.58/ 1.55/ 0.94; 6.88. Leg III: 1.72/ 0.78/ 1.25/ 1.50/ 0.87/ 6.12. Leg IV: 2.22/ 0.81/ 1.83/ 2.19/ 1.02; 8.07.

Similar to male in coloration. Carapace longer than that of male. Head region large, ratio of width to thoracic region 0.71. Abdomen larger and more rounded, legs shorter than those of male. Tibia I with 2-2-2-2 ventral spines, 2 prolateral spines and 2 retrolateral spines; metatarsus I with 2-2-3 ventral spines, 1 prolateral spine and 1 retrolateral spine; tibia II with 2-2-1(retromargin)-2 ventral spines and 2 (left) or 3 (right) prolateral spines; metatarsus II 2-2-3 ventral spines, 4 prolateral spines and 1 retrolateral spine.

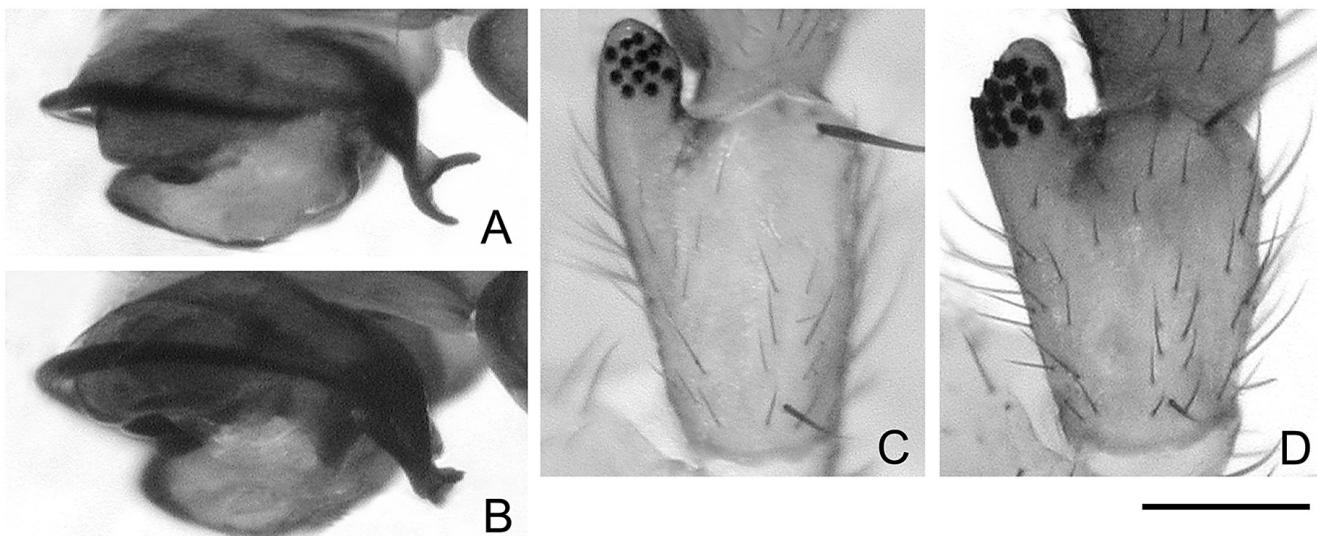
**Genitalia** (Fig. 15A, C). Opening of epigynum small, anterior rim convexly curved anteriorly (Fig. 15A). Spermathecal bases sphere (Fig. 15C).

**Type series.** Mt. Noine-dake, Kawanishi, Yufuin-chō, Yufu-shi, Oita Pref., Japan: holotype (♂, NSMT-Ar 6806); paratypes (1♂2♀, NSMT-Ar 6807-6809), 10-X-1995, Y. Ihara leg.

**Other specimens examined.** FUKUOKA PREF. Buzen-shi, Kubote, 1♀, 19-XI-1994, YI. Miyako-gun, Miyakomachi, Hobashira, surrounding of Jabuchi campsite: 3♂1♀, 19-XI-2005, YI; 1♂, 7-IV-2006, YI. OITA PREF. Yufu-shi, Yufuin-chō, Kawanishi, northern foot of Mt. Noine-dake, 1♂, 10-X-1995, YI. Shonai-chō, Nobatake, 2♀, 11-X-1993, YI.

**Distribution.** Fukuoka Prefecture, Oita Prefecture and Kumamoto Prefecture (Irie & Ono 2003), Kyushu, Japan (Fig. 1).

**Variation.** No prominent variation is found in the mor-



**Fig. 16.** Male left palp of the unsettled populations belonging to *Cybaeus kuramotoi*-group: A-B, apical element of embolus, ventrolateral view; C-D, patellar apophysis, dorsolateral view — A & C, Oita population, Kunisaki; B & D, Saga population, Mt. Sefuri. (Scale: 0.2 mm)

phology of male palp and female genitalia.

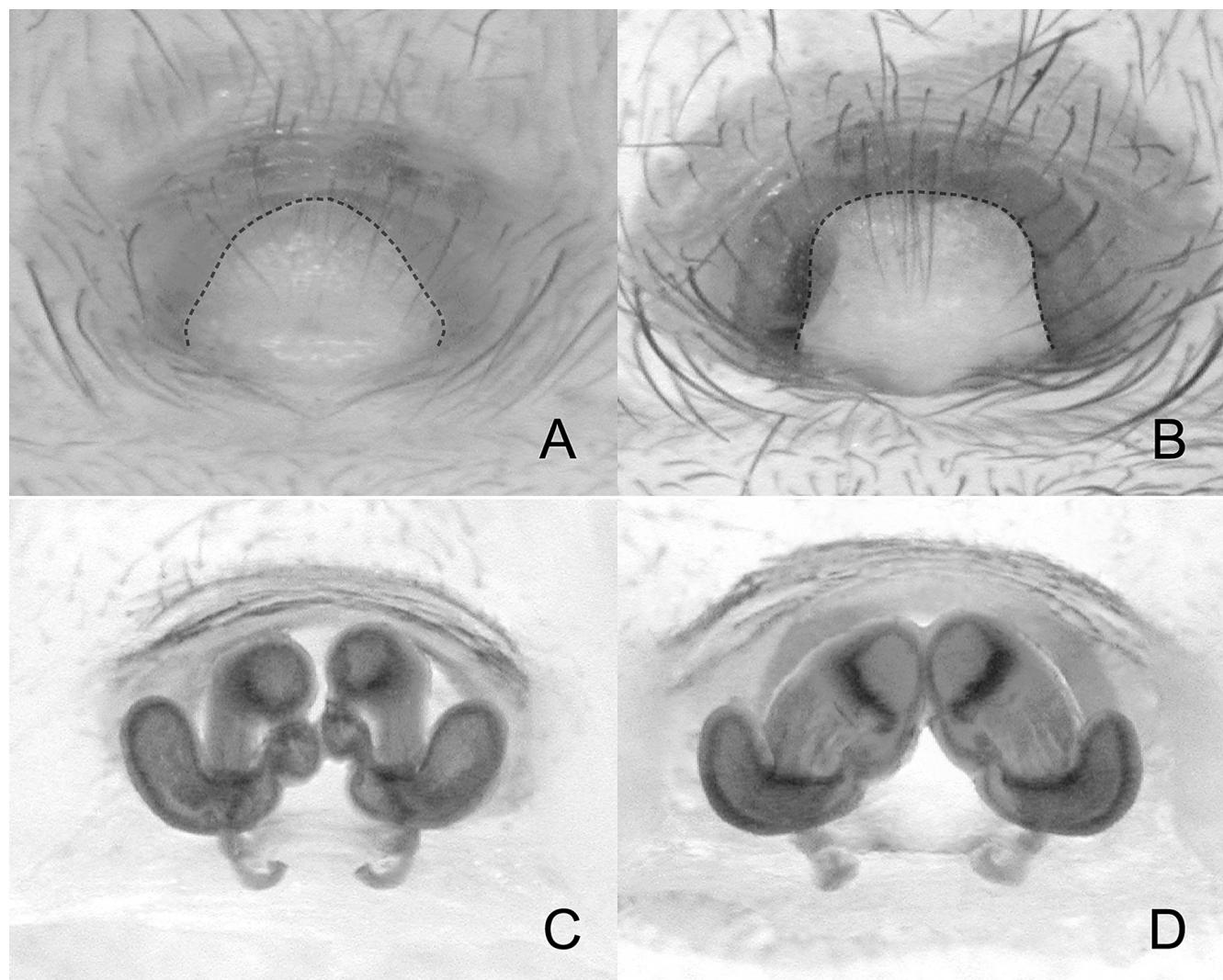
*Remarks.* Male palp of *C. yufuin* resembles that of *C. ashikitaensis*, which is sympatrically found inhabiting northern Kyushu, by having short tibia and simple conductor compared with those of *C. kuramotoi*. However, male *C. yufuin* is distinguished from male *C. ashikitaensis* by the length of palpal patella (cf. Fig. 13D with 13C) and thick cymbium. Furthermore, female genitalia of these species are rather distinct each other.

Fundamental structures of male palp and female genitalia of *C. yufuin* resemble rather those of *C. akiensis* Ihara 2003 than *C. ashikitaensis*. However, *C. yufuin* is distinguished from *C. akiensis* by the round top of patellar apophysis of male palp against triangle top of *C. akiensis*. In female *C. yufuin*, genital opening is small, and internal structure of genitalia is considerably different from that of female *C. akiensis* (cf. Fig. 15 A with B and C with D). Furthermore,

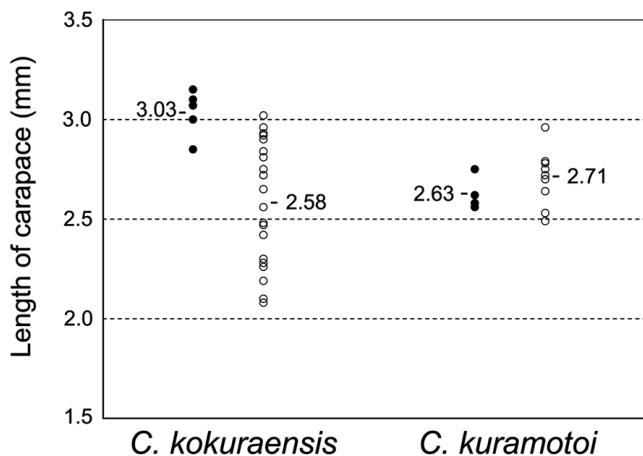
their distributions are separated into two different areas, Kyushu (*C. yufuin*) and Honshu (*C. akiensis*).

#### Unsettled populations

The following populations of the medium-sized *Cybaeus* in Oita and Saga Prefectures undoubtedly belong to the *kuramotoi*-group defined by Ihara & Nojima (2004) in having a mating plug. They show close affinities to *C. kuramotoi* in genital morphology of both sexes (Figs. 16–17). However, it is difficult to judge objectively whether they are distinct biological species or mere geographical variants of *C. kuramotoi*, because no information is available for the reproductive isolation between these populations and populations of *C. kuramotoi* due to their allopatric pattern of the distribution. Therefore, I will provisionally treat each of them as an uncategorized population in this study.



**Fig. 17.** Female genitalia of the unsettled populations belonging to *Cybaeus kuramotoi*-group: A-B, epigynum, the shape of genital opening, ventral view; C-D, internal structure, dorsal view — A & C, Oita population, Kunisaki; B & D, Saga population, Mt. Sefuri. (Dashed line: edge of epigynal plate, Scale: 0.2 mm)



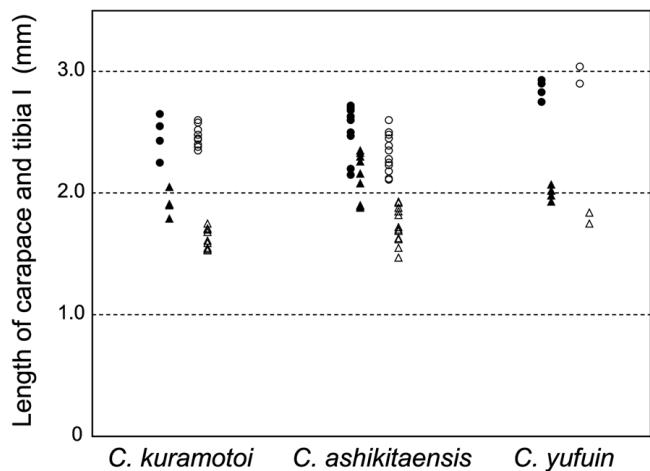
**Fig. 18.** Length of carapace of two *Cybaeus* species (*C. kokuraensis* and *C. kuramotoi*) sympatrically found in eastern part of Fukuoka Prefecture, northern Kyushu (Solid: males, open: females). Specimens from three adjacent localities were pooled since no significant difference was found among them for the carapace length. Difference in carapace length between the two species was significant in males ( $P < 0.05$ , Mann-Whitney U-test), but not in females.

*Unsettled populations.* OITA PREF. Yufu-shi, Shônai-chô, Nobatake, 2♂3♀, 11-X-1993, YI. Kunisaki-shi: Kunisakimachi, Jobutsu, eastern foot of Mt. Futago, 2♂4♀, 9-X-1993, YI, 1♂1♀, 9-X-1993, M. Ihara; Kunimi-chô, Takedazu, 1♂, 22-I-1993, YI. SAGA PREF. Kanzaki-shi, Sefuri-machi: Haramaki, 2♂4♀, 19-XI-2005, YI; Mt. Sefuri, 1♀, 30-XII-2005, KO.

#### Body sizes in the sympatric species

*Cybaeus kokuraensis* has been found within a distributional range of *C. kuramotoi* (Fig. 1). Figure 18 represents body size of the two species in the northern part of Fukuoka Prefecture, where the two species occur sympatrically. Although both species are medium in size among the species of Japanese *Cybaeus*, there is a slight difference in carapace length between the species. Male *C. kokuraensis* is significantly longer in carapace than male *C. kuramotoi* ( $P < 0.05$ , Mann-Whitney U-test). However, no significant difference was detected between females of both species ( $P > 0.05$ , Mann-Whitney U-test).

On the other hand, of the present three medium-sized species, *C. kuramotoi*, *C. ashikitaensis* and *C. yufuin*, are sympatrically distributed in the southern area of Fukuoka Prefecture (Fig. 1). Lengths of carapace and tibia of leg I of these species in the area are as shown in Fig. 19. There was a slight but significant difference ( $P = 0.01$  for males;  $P = 0.02$  for females: Kruskal-Wallis test) in body size among the three species, although no significant difference was found in length of tibia I. That is, *C. yufuin* is apparently larger than the other two species, although body size of *C. kuramotoi* and *C. ashikitaensis* are equivalent.



**Fig. 19.** Lengths of carapace (circles) and tibia of leg I (triangles) of three *Cybaeus* species (*C. kuramotoi*, *C. ashikitaensis* and *C. yufuin*) sympatrically distributed in Fukuoka Prefecture, northern Kyushu (Solid: males, open: females). Specimens from two adjacent localities (Jabuchi Falls and Kubote) were pooled since no significant difference was found between the two. Difference in body length among the three species was significant in both males ( $P = 0.01$ ) and females ( $P = 0.02$ , Kruskal-Wallis test), while that in tibia length was not.

#### Discussion

Generally, it is envisaged that divergence in body size between two ecologically similar species serves to resource partitioning or reproductive isolation between them (Tokeshi 1999). Occurrence of a series of segregated size classes in a local species assemblage in Japanese *Cybaeus* species may illustrate the general assumption above. A pair of newly formed species which arose from an allopatric speciation event would coexist in the same area after a secondly contact, when they differ sufficiently in size. On the other hand, resource competition or reproductive interference is expected to occur between those species after a secondly contact if they are similar in size and unless otherwise diverged.

In sympatric populations of *Cybaeus kokuraensis* and *C. kuramotoi* in northern Kyushu, males of *C. kokuraensis* are larger than those of *C. kuramotoi*, although their females seem to be not diverged in body size. The increased body size in males of *C. kokuraensis* leads to enlarged male palp. Thus, it is probable that the size difference of genitalia reinforces reproductive isolation between the two species although further studies on pre- and postzygotic isolation between two species will be necessary.

On the other hand, when two similar-sized species of the genus coexist in the same local area, coloration of those species is often different from one another. For example, *C. ashikitaensis* is paler in coloration than *C. kuramotoi* in northern Kyushu (Fig. 8). The difference in body color may represent difference in microhabitat preferences between the two sympatric species. In several caves in Kita-Kyushu-shi, northern Kyushu, where *C. ashikitaensis* (as *C. sp.*) and *C.*

*kuramotoi* are sympatrically found, *C. ashikitaensis* tends to inhabit deeper portions of the caves compared to *C. kuramotoi* living near the surface of the ground (Kuramoto & Mashibara 1995). Generally, the cave spiders tend to dis-color compared with the related species inhabiting outside caves.

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